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(54) **SOLID-STATE IMAGING DEVICE AND METHOD OF MANUFACTURING THE SAME.**

(57) By determining the curvatures or wall thicknesses of condensing lenses over photosensitive parts independently of each other, in spite of the shapes of photosensitive pixels (photosensitive parts) i.e. even in the case where the length in row direction is longer than that in column direction, light is directed to the respective photosensitive parts. Over the photosensitive parts in columns of the ones arranged in the form of a matrix, belt-like layers are formed, and the condensing lenses are formed on those band-like layers, to obtain the desired curvatures or wall thicknesses.

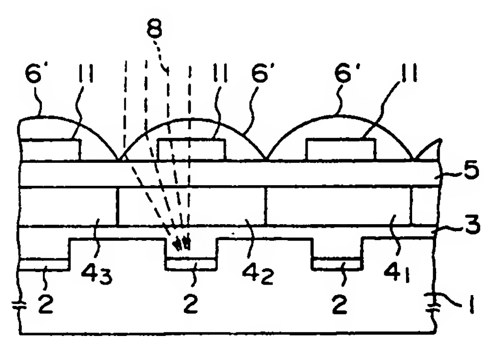

FIG. 1A

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FIELD OF THE INVENTION

The present invention relates to a solid state image pickup device and a method of manufacturing the same.

BACKGROUND OF THE INVENTION

A solid state image pickup device is constructed of a plurality of pixels of image pickup elements each having a photosensitive section. In each image pickup element, light incident to a light receiving section is converted into electric charge signal by the photosensitive section (e.g., a photodiode). This electric charge signal is outputted from a charge transfer section of the solid state image pickup device.

As a method of improving the light reception sensitivity of such a solid state image pickup device without enlarging a light receiving section, a light converging lens is mounted above a photodiode (photosensitive section) to converge external light onto the photosensitive section.

A conventional method of manufacturing a solid state image pickup device having a light converging lens will be described with reference to Figs. 13A to 13D.

As seen from Fig. 13A, a plurality of photosensitive sections (photodiodes) 2 are first formed on the surface of a semiconductor substrate 1 at predetermined areas. The surface of the photodiodes 2 is covered with a passivation film 3. Color filters 4_1, 4_2 and 4_3 are formed on the surface of the passivation film 3, using a dying film such as gelatin. The color filters 4_1, 4_2 and 4_3 are red, green, and blue, respectively. A passivation film 5 is deposited on the surface of these color filters 4_1, 4_2 and 4_3.

Next, as seen from Fig. 13B, a photoresist film 6A is formed over the whole surface of the passivation film 5. The photoresist film 6A is patterned to form a photoresist film 6 above each photodiode 2.

Thereafter, as shown in Fig. 13C, light 7 is applied to the photoresist films 6 to make them transparent.

Then, as shown in Fig. 13D, the transparent films 6 are thermally deformed to form light converging lenses 6'.

Figs. 11A to 11C show a conventional solid state image pickup device manufactured by the above-described method. Fig. 11C is a plan view, Fig. 11A is a cross sectional view taken along the A_5-$A_{5'}$ of Fig. 11C, and Fig. 11B is a cross sectional view taken along line B_5-$B_{5'}$ of Fig. 11C. Fig. 11A corresponds to Fig. 13D.

Another conventional manufacturing method will be described with reference to Figs. 14A to 14D.

The processes up to forming a passivation film 5 shown in Fig. 11A are the same as those described with Fig. 13A. A transparent film 106 to form light converging lenses 106' (refer to Fig. 14D) is formed on the passivation film 5.

Next, as seen from Fig. 14B, a photoresist layer 107A is formed on the transparent film 106. The photoresist layer 107A is patterned by means of a photoetching method, to form a photoresist film 107 patterned so as to form light converging lenses. Thereafter, as seen from Fig. 14C and 14D, the transparent film 106 and photoresist film 107 are etched by means of an anisotropic etching (e.g., RIE). The shape of the photoresist film 107 is therefore transferred to the transparent film 106 to form the light converging lenses 106'. The plan view and cross sectional view along line B_5-$B_{5'}$ of this device are shown in Figs. 11C and 11B.

As shown in Fig. 14B, the photoresist film 107 of a solid state image pickup device manufactured by the method explained with Figs. 14A to 14D is formed on a flat passivation film 5. Therefore, the film thickness is substantially the same both in the X- and Y-directions. Thus, the curvatures in the X- and Y-directions are determined by the shape of the photoresist film 107 patterned so as to form the light converging lenses. The light convergence efficiency in the direction along line A_5-$A_{5'}$ of the light converging lens 6' (106') shown in Fig. 11A is good because light is refracted by the light converging lens 6' and directed to the center of the photodiode 2. However, the light convergence efficiency in the direction along line B_5-$B_{5'}$ is not so good because of a so-called "circular aberration" phenomenon caused by a larger curvature at the plane along line B_5-$B_{5'}$ of the light converging lens 6' (106') than that along line A-A. Specfically, as seen from Fig. 12 showing the lens effects, light in the Y-direction (B-B direction) can be sufficiently converged, but light in the X-direction (A-A direction) cannot be sufficiently converged. Therefore, an effective light convergence area 9 becomes small. In other words, the light convergence of the light converging lens 6 becomes small.

If the curvature is set so that light in the Y-direction can be sufficiently converged, the length of each pixel becomes greater in the X-direction than in the Y-direction. Therefore, contrary to the above-described case, light in the X-direction cannot be sufficiently converged. Most of light near each photodiode cannot be used accordingly. This is serious particularly for a PAL method having more pixels in the vertical direction than the horizontal direction.

As described above, a conventional device cannot obtain a sufficiently large effective light convergence area 9 (Fig. 12). Therefore, if the ratio of

an X-direction width to a Y-direction width of the micro light converging lens 6' (106') changes, the light converging lens effects in the Y-direction may disappear in some cases. Namely, both opposite areas in the Y-direction of the photodiode 2 may become an invalid light convergence area 10. As a result, light incident to the invalid light convergence area 10 may enter adjacent photodiodes, resulting in a problem of increased color crosstalk, smear, and the like.

It is conceivable that the curvature is made small by thinning the film thickness of the light converging lens 6' (106') at the cross section in the Y-direction or along line B_5-$B_{5'}$. However, this essentially makes small the curvature of the light converging lens at the cross section in the X-direction or along line A_5-$A_{5'}$. The effective light convergence area therefore becomes small. If the length in the X-direction of the photodiode is made large to compensate for the reduced effective light convergence area, the problem of increased smear will occur.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above circumstances. It is therefore an object of the present invention to provide a solid state image pickup device and a method of manufacturing the same, capable of obtaining a high light reception sensitivity irrespective of the size of each pixel.

According to the solid state image pickup device of the present invention, a suitable curvature or thickness of a light converging lens is set. Therefore, light incident to the light converging lens either in the row direction or in the column direction, can be converged efficiently to the corresponding photosensitive section, considerably improving the light reception sensitivity.

According to the method of manufacturing a solid state image pickup device of the present invention, a strip layer is formed above photosensitive sections disposed in the column line to form light converging lenses by directly or indirectly using the strip layer. Therefore, it is possible to control the curvature or thickness of a light converging lens independently at cross sections in the row and column directions, and to obtain a solid state image pickup device capable of efficiently converging incident light in the row and column directions to the photosensitive section.

In the solid state image pickup device of the present invention, photosensitive sections of respective solid state image pickup elements are disposed in a matrix shape, and each light converging lens is positioned above each photosensitive section. The curvatures of each light converging lens, i.e., a first curvature at the cross section in the row direction of the matrix and a second curvature at the cross section in the column direction, are set to such values that light incident to each light converging lens in the row and column directions is directed to the corresponding photosensitive section. Therefore, irrespective of the shape of a photosensitive section, for example, irrespective of different side lengths in the row and column directions, light incident to each light converging lens in the row and column directions is directed to the corresponding photosensitive section.

According to another solid state image pickup device of the present invention, a desired thickness of a light converging lens is set. Therefore, light incident to each light converging lens in the row and column directions, is directed to the corresponding photosensitive section, similar to the above-described device, irrespective of the shape of a photosensitive section, for example, irrespective of the side lengths in the row and column directions.

According to a method of manufacturing a solid state image pickup device of the present invention, a strip layer is formed above a plurality of photosensitive sections disposed in the row direction. An outer portion of each light converging lens is formed on the strip layer. Therefore, the curvature of each light converging lens can be controlled independently at cross sections in the row and column directions. It is therefore possible to obtain a solid state image pickup device having light converging lenses capable of directing light incident in the row and column directions to the corresponding photosensitive sections.

According to another method of manufacturing a solid state image pickup device of the present invention, a strip layer is formed above a plurality of photosensitive sections disposed in the row direction. A lens shape is formed on the strip layer by using the strip layer, the thickness of the lens form being controlled independently at cross sections in the row and column directions. The lens shape is transferred to form a light converging lens. Therefore, it is possible to obtain a solid state image pickup device having suitable controlled thicknesses at cross sections in the row and column directions.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a cross sectional view taken along line A_1-$A_{1'}$ of a solid state image pickup device according to a first embodiment of the present invention;

Fig. 1B is a cross sectional view taken along line B_1-$B_{1'}$ of the solid state image pickup device of

the first embodiment;

Fig. 1C is a plan view of the solid state image pickup device of the first embodiment;

Fig. 2 is a plan view explaining the advantageous effects of the first embodiment;

Figs. 3 and 4 show processes of a method of manufacturing the solid state image pickup device of the first embodiment;

Fig. 5A is a cross sectional view taken along line A_2-$A_{2'}$ of a solid state image pickup device according to a second embodiment of the present invention;

Fig. 5B is a cross sectional view taken along line B_2-$B_{2'}$ of the solid state image pickup device of the second embodiment;

Fig. 5C is a plan view of the solid state image pickup device of the second embodiment;

Fig. 6A is a cross sectional view taken along line A_3-$A_{3'}$ of a solid state image pickup device according to a third embodiment of the present invention;

Fig. 6B is a cross sectional view taken along line B_3-$B_{3'}$ of the solid state image pickup device of the third embodiment;

Fig. 6C is a plan view of the solid state image pickup device of the third embodiment;

Fig. 7A is a cross sectional view along line A_4-$A_{4'}$ of a solid state image pickup device manufactured by the method of the present invention;

Fig. 7B is a cross sectional view along line B_4-$B_{4'}$ of the solid state image pickup device manufactured by the method of the present invention;

Fig. 7C is a plan view of the solid state image pickup device manufactured by the method of the present invention;

Fig. 8 is a plan view explaining the advantageous effects of the solid state image pickup device shown in Fig. 7;

Figs. 9A to 9E and Figs. 10A to 10E are cross sectional views showing the processes of manufacturing the solid state image pickup device shown in Figs. 7A to 7C;

Fig. 11A is a cross sectional view along line A_5-$A_{5'}$ of a conventional solid state image pickup device;

Fig. 11B is a cross sectional view along line B_5-$B_{5'}$ of the conventional solid state image pickup device;

Fig. 11C is a plan view of the conventional solid state image pickup device;

Fig. 12 is a plan view explaining the disadvantages of the conventional solid state image pickup device; and

Figs. 13 and 14 are cross sectional views showing the processes of manufacturing conventional solid state image pickup devices.

EMBODIMENTS

A solid state image pickup device according to the first embodiment of the present invention will be described with reference to Figs. 1A to 1C and Fig. 2.

The plan view of the solid state image pickup device of the first embodiment is shown in Fig. 1C, the cross sectional view along line A_1-$A_{1'}$ is shown in Fig. 1A, and the cross sectional view along line B_1-$B_{1'}$ is shown in Fig. 1B.

The solid state image pickup device of the first embodiment is constructed of the following elements. Namely, it has a plurality of photodiodes 2 formed on the surface of a semiconductor substrate 1 at predetermined areas, a passivation film (protective film) 3 for protecting the photodiodes, color filters 4_1, 4_2, and 4_3 formed on the passivation film 3 for the respective photodiodes 2, a passivation film 5 for protecting the color filters 4_1, 4_2, and 4_3, transparent strip layers 11 formed on the passivation film 5 above the photodiodes 2, and light converging lenses 6' covering the transparent strip layers 11. The photodiodes 2, passivation film 3, color filters 4_1, 4_2, and 4_3, and passivation film 5 are the same as conventional elements, so the description thereof is omitted. The strip layers 11 are made of transparent material and formed running in the Y-direction as seen from Fig. 1C. The cross section of the strip layer 11 along line A-A is rectangular as seen from Fig. 1A. The width of the strip layer 11 in the direction along the longer side of the photodiode 2 (X-direction shown in Fig. 1C) is greater than the width of the photodiode 2 in the X-direction. The length of the strip layer 11 in the Y-direction is set such that it continuously covers a plurality of photodiodes 2 disposed in the Y-direction. Each light converging lens 6' is provided for each photodiode 2, and formed above each strip layer 11. As seen from Fig. 1A, the curvature of the light converging lens 6' at the cross section taken along line A_1-$A_{1'}$ is substantially the same as that of a conventional device. However, as seen from Fig. 1B, the curvature of the light converging lens 6' at the cross section along line B_1-$B_{1'}$ is different. Namely, the thickness of the light converging lens 6' at the cross section along line B-B, i.e., the thickness effective for light convergence, is thinner than that of a conventional device. A desired value of curvature of the light converging lens 6' can be therefore obtained, and almost all light incident to the light converging lens 6' can be converged to the corresponding photodiode 2.

As a result, as shown in Fig. 2, almost all external light 8 incident to the light converging lens 6' can be converged to the photodiode 2 not only in the X-direction but also in the Y-direction, i.e., in the omnidirectional manner. Therefore, as compared to a conventional device, an effective light convergence area 9 becomes large, improving the

light reception sensitivity.

Furthermore, in the first embodiment, as seen from Figs. 1A to 1C, adjacent two light converging lenses 6' are disposed as near as possible, and each light converging lens 6' has a curvature allowing almost all light incident to each light converging lens 6' to be converged to the corresponding photodiode 2. Therefore, an area not allowed for external light to be incident to the photodiode 2 can be made small. For example, consider a conventional solid state image pickup device having a pixel dimension of 9.6 µm width × 9.6 µm height and a photodiode dimension of 2 µm width × 3 µm height. In this case, the width of the invalid light convergence area 10 is about 2.0 µm at the maximum. In contrast, the width of the invalid light convergence area 10 of the solid state image pickup device of the first embodiment, is as small as about 0.5 µm at the maximum. From the macro viewpoint, almost all the light receiving section of the solid state image pickup device is substantially covered with a set of light converging lenses 6'. As a result, flare and smear are suppressed, improving the reliability of the solid state image pickup device.

A method of manufacturing the solid state image pickup device of the first embodiment will be described with reference to Figs. 3A to 3D and Figs. 4A to 4D.

Figs. 3A to 3D are cross sectional views along line A_1-$A_{1'}$ of Fig. 1C showing manufacturing processes, and Figs. 4A to 4D are cross sectional views along line B_1-$B_{1'}$.

In Figs. 3A and 3B, manufacturing processes same as conventional are used until a passivation film 5 is formed.

As seen from Figs. 3B and 4B, a film 11A is formed on the passivation film 5, using styrene based resist or acrylic based resist. This film 11A is patterned to form a plurality of transparent strip layers 11 each having a predetermined dimension and continuously covering a plurality of photodiodes 2, 2, ... disposed in the Y-direction.

Thereafter, as seen from Figs. 3C and 4C, a positive photoresist film 6A is formed covering the strip layers 11. The positive photoresist film 6A is patterned in a predetermined shape by means of a photoetching method. Each patterned positive photoresist film 6 is made transparent, for example, by applying light thereto.

Thereafter, as seen from Figs. 3D and 4D, light converging lenses 6', 6', ... are formed through thermal deformation.

With the above-described manufacturing method, it is possible to obtain the film thickness of the light converging lens 6' at an area effective for light convergence, different in the X-direction and Y-direction, which the conventional device cannot obtain. In this manner, desired curvatures of the light converging lens 6' can be obtained at all the circumference of the lens. Therefore, almost all light incident to the light converging lens 6' can be converged to the corresponding photodiode 2.

Next, a solid state image pickup device according to the second embodiment of the present invention will be described with reference to Figs. 5A to 5C. The plan view of the solid state image pickup device of the second embodiment is shown in Fig. 5C, the cross section taken along line A_2-$A_{2'}$ of Fig. 5C is shown in Fig. 5A, and the cross section taken along line B_2-$B_{2'}$ of Fig. 5C is shown in Fig. 5B.

As seen from Figs. 5A and 5B, the different points of the second embodiment from the first embodiment reside in that a passivation film 11' made of transparent material for protecting transparent layers 11 is formed between the layers 11 and light converging lenses 6', and that the cross section of the strip layer 11 along line A_2-$A_{2'}$ is made generally of a trapezoidal shape. In the second embodiment, like elements to those of the first embodiment are represented by using identical reference numerals, and the description thereof is omitted.

In the second embodiment, the strip layers 11 are covered with the passivation film 11'. Therefore, as the material of the strip layer 11, it is possible to use styrene based or acrylic based negative photoresist, increasing the degree of freedom of material selection. It is preferable to use, as the material of the passivation layer 11', material which does not intermixed with the material of the light converging lens 6'.

The solid state image pickup device of the second embodiment can have desired curvature of the light converging lens 6' and the advantageous effects, similar to the first embodiment. Furthermore, the strip layers 11 are covered with the passivation film 11', so that the strip layers 11, particularly their corners, will not be exposed even if the film thickness of the lens 6' becomes thin, as different from the first embodiment, thus improving the reliability of the device. The third embodiment of the present invention is shown in Figs. 6A to 6C. The plan view of the solid state image pickup device of the third embodiment is shown in Fig. 6C, the cross section taken along line A_3-$A_{3'}$ of Fig. 6C is shown in Fig. 6A, and the cross section taken along line B_3-$B_{3'}$ of Fig. 6C is shown in Fig. 6B.

For the solid state image pickup device of the third embodiment, the processes up to forming a passivation film 5 for protecting color filters 4_1, 4_2, and 4_3 are performed in a similar manner to the first embodiment. Thereafter, formed on the passivation film 5 are light converging lenses 6_0, each constructed of a first light converging lens 6_1, and

a second light converging lens 6_2. The first light converging lens 6_1, has a cross section along line A_3-$A_{3'}$ of generally a crescent moon shape. This lens 6_1 extends in the Y-direction to cover a plurality of photodiodes 2, 2, ... disposed in the Y-direction.

The first light converging lens $6_{1'}$ can be considered as a strip layer having a curvature effective for light convergence. As a result, similar to the first and second embodiments, in the third embodiment, the second light converging lenses $6_{2'}$ can be considered as covering the strip layers (first light converging lenses $6_{1'}$). Each second light converging lens $6_{2'}$ covers the first light converging lens $6_{1'}$ for the corresponding photodiode 2. Therefore, the curvature of the light converging lens $6_{0'}$ at the cross section along line A_3-$A_{3'}$ is determined by the light converging lenses $6_{1'}$ and $6_{2'}$, and the curvature at the cross section along line B_3-$B_{3'}$ is determined by the light converging lens $6_{2'}$. It is therefore possible to have desired curvatures at the cross sections along line A_3-$A_{3'}$ and line B_3-$B_{3'}$. If adjacent two second light converging lenses $6_{2'}$ are disposed as near as possible, the invalid light convergence area 10 can be made small, obtaining the advantageous effects similar to the first embodiment.

In the third embodiment, it is preferable to use as the material of the first light converging lens $6_{1'}$, material which does not intermixed with the material of the second light converging lens $6_{2'}$. For example, material added with thermosetting agent may be used as the material of the first light converging lens $6_{1'}$. Raw material is deformed thermally to obtain the shape of the lens $6_{1'}$ shown in Fig. 6A, and thereafter it is thermally set to form the light converging lens $6_{1'}$. Thereafter, a lens raw material layer is formed on the first light converging lens $6_{1'}$ and etched to form the second light converging lens $6_{2'}$. In this manner, it is possible not to intermix together the materials of the first and second light converging lenses $6_{1'}$ and $6_{2'}$.

Also in the third embodiment, the light converging lens $6_{0'}$ is constructed of two-layered lenses $6_{1'}$ and $6_{2'}$, so that it can be made thicker than a single layer lens. A thick single layer poses a problem of a low patterning precision. However, a multi layer eliminates this problem.

Next, a solid state image pickup device according to the fourth embodiment of the present invention will be described with reference to Figs. 7A to 7C. The plan view of the solid state image pickup device of the fourth embodiment is shown in Fig. 7C, the cross section taken along line A_4-$A_{4'}$ of Fig. 7C is shown in Fig. 7A, and the cross section taken along line B_4-$B_{4'}$ of Fig. 7C is shown in Fig. 7B.

First, the processes of manufacturing the solid state image pickup device of the fourth embodiment will be described with reference to Figs. 9A to 9E and Figs. 10A to 10E.

Similar to Fig. 3A, as seen from Figs. 9A and 10A, formed on a semiconductor substrate 1 are photodiodes 2, passivation film 3, color filters 4_1, 4_2, and 4_3, and passivation film 5.

As seen from Figs. 9B and 10B, a transparent film layer 106 is formed on the passivation film 5.

As seen from Figs. 9C and 10C, strip layers 11' like the strip layers 11 shown in Fig. 3C are formed on the film layer 106. A resist film 6 like the positive photoresist film 6 shown in Fig. 3C is formed on the strip layers 11'.

Next, as shown in Figs. 9D and 10D, the resist film 6 is heated to obtain the lens shape 6". Since the light converging lens is formed at the later process by etching a transparent film, the strip layers 11' and lens shape layer 6" are not necessary to use transparent material. Therefore, the degree of freedom of selecting the material for these layers 11' and 6" can be broaden.

Thereafter, as seen from Figs. 9E and 10E, anisotropic etching is carried out using O_2 RIE for example. The lens shape 6" is therefore transferred to a transparent film layer 106 to form light converging lenses 106'.

Similar to the first embodiment, the solid state image pickup device manufactured in the above manner can obtain desired curvatures of the light converging lens 106' at the cross sections along line A_4-$A_{4'}$ and line B_4-$B_{4'}$. Therefore, as shown in Fig. 8, almost all light incident to the light converging lens 106' can be converged to the corresponding photodiode 2, considerably improving the light reception sensitivity similar to the first embodiment. In manufacturing a solid state image pickup device, instead of forming strip layers and patterns for light converging lenses as used in the first embodiment, light converging lenses as used in the first embodiment, light converging lenses 106' may be formed by transferring patterns to a transparent film layer by means of anisotropic etching, after forming strip layers and patterns for light converging lenses as used in the second embodiment, or after forming strip layers and patterns for light converging lenses as used in the third embodiment.

In the above embodiments, the cross section of the strip layer has a rectangular shape, trapezoidal shape or crescent moon shape. The present invention is not limited thereto, but any other shape may be used so long as it provides the above-described function of the strip layer.

In the foregoing description, a solid state image pickup device having color filters has been used by way of example. The present invention is not limited thereto. Obviously, the present invention can be applied to solid state image pickup devices without color filters.

Claims

1. A solid state image pickup device comprising:
a semiconductor substrate (1);
a plurality of solid state image pickup elements formed on said semiconductor substrate (1), each said solid state image pickup element including a photosensitive section (2) for converting incident light (8) into an electric charge signal, said photosensitive sections (2) being disposed on the surface of said substrate (1) generally in a matrix form, and each said photosensitive section (2) having one side in the row direction longer than the other side in the column direction; and
a plurality of light converging lenses (6', 11; 6', 11, 11'; $6_{1'}$, $6_{2'}$) formed above said plurality of photosensitive sections (2), each said light converging lens being provided for each said photosensitive section (2), each said light converging lens having a first curvature at a cross section in the row direction and a second curvature at a cross section in the column direction, respectively set independently from each other, and light (8) incident to each said light converging lens in the row and column directions being refracted toward each said photosensitive section corresponding to each said light converging lens.

2. A solid state image pickup device according to claim 1, wherein said first and second curvatures of each said light converging lens are set to such values that light incident in the row and column directions is converged near to the center of each said photosensitive section (2) corresponding to each said light converging lens.

3. A solid state image pickup device according to claim 1, wherein each said light converging lens is constructed of a laminated layer of a plurality of layers.

4. A solid state image pickup device according to claim 3, wherein each said light converging lens (6', 11; $6_{1'}$, $6_{2'}$) includes an inner layer (11; $6_{1'}$) above each said photosensitive section (2) and an outer layer (6'; $6_{2'}$) covering said inner layer (11; $6_{1'}$).

5. A solid state image pickup device according to claim 4, wherein a plurality of said inner layers (11; $6_{1'}$) of said photosensitive sections disposed in the column direction are continuously coupled to form a strip layer (11; $6_{1'}$).

6. A solid state image pickup device according to claim 5, wherein the cross section of said strip layer (11) in the row direction is generally of a rectangular shape.

7. A solid state image pickup device according to claim 5, wherein the cross section of said strip layer ($6_{1'}$) in the row direction is generally of a semicircular shape.

8. A solid state image pickup device according to claim 6, wherein said outer layer (6') covers the upper surface and opposite sides of said inner layer (11) at the cross section in the row direction, and covers the upper surface of said inner layer (11) at the cross section in the column direction.

9. A solid state image pickup device according to claim 6, wherein said outer layer (6') covers the arcuate portion of said inner layer ($6_{1'}$) at the cross section in the row direction, and covers the corner portions of said inner layer ($6_{1'}$) at the cross section in the column direction.

10. A solid state image pickup device according to claim 8, wherein each said photosensitive section (2) is formed of a rectangular shape having one side in the row direction longer than the other side in the column direction.

11. A solid state image pickup device according to claim 9, wherein each said photosensitive section (2) is formed of a rectangular shape having one side in the row direction longer than the other side in the column direction.

12. A solid state image pickup device according to claim 1, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses and corresponding photosensitive sections.

13. A solid state image pickup device according to claim 4, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses and corresponding photosensitive sections.

14. A solid state image pickup device according to claim 5, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses and corresponding photosensitive sections.

15. A solid state image pickup device according to claim 8, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses and corresponding photosensitive sections.

16. A solid state image pickup device according to

claim 9, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses and corresponding photosensitive sections.

17. A solid state image pickup device according to claim 3, wherein each said light converging lens (6', 11, 11') includes an inner layer (11) above each said photosensitive section (2), an intermediate layer (11') made of an optional number of layers covering said inner layer (11), and an outer layer (6') covering said intermediate layer (11').

18. A solid state image pickup device according to claim 17, wherein a plurality of said inner layers (11) of said photosensitive sections disposed in the column direction are continuously coupled to form a strip layer (11).

19. A solid state image pickup device according to claim 18, wherein each said inner layer (11) is made of a planar member collectively covering a plurality of upper surfaces of said strip layers and a plurality of gaps between said strip layers.

20. A solid state image pickup device according to claim 19, wherein said outer layer (6') covers said intermediate layer (11') and positioned above said inner layer (11), and the shape of said outer layer (6') is set such that an arcuate portion length at the cross section in the row direction is shorter than an arcuate portion length at the cross section in the column direction.

21. A solid state image pickup device according to claim 20, wherein each said photosensitive section (2) is formed of a rectangular shape having one side in the row direction longer than the other side in the column direction.

22. A solid state image pickup device according to claim 17, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses (6', 11, 11') and corresponding photosensitive sections (2).

23. A solid state image pickup device according to claim 18, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses (6', 11, 11') and corresponding photosensitive sections (2).

24. A solid state image pickup device according to claim 19, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses (6', 11, 11') and corresponding photosensitive sections (2).

25. A solid state image pickup device according to claim 20, wherein color filters (4_1; 4_2; 4_3) are formed between said light converging lenses (6', 11, 11') and corresponding photosensitive sections (2).

26. A solid state image pickup device comprising:

a semiconductor substrate (1);

a plurality of solid state image pickup elements formed on said semiconductor substrate (1), each said solid state image pickup element including a photosensitive section (2) for converting incident light (8) into an electric charge signal, said photosensitive sections (2) being disposed on the surface of said substrate (1) generally in a matrix form, and each said photosensitive section (2) having one side in the row direction longer than the other side in the column direction; and

a plurality of light converging lenses (106') formed above said plurality of photosensitive sections (2), each said light converging lens (106') being provided for each said photosensitive section (2), each said light converging lens having a first thickness at a cross section in the row direction and a second thickness at a cross section in the column direction, respectively set independently from each other, and light (8) incident to each said light converging lens in the row and column directions being refracted toward each said photosensitive section (2) corresponding to each said light converging lens.

27. A solid state image pickup device according to claim 26, wherein said first and second thicknesses of each said light converging lens (106') are set to such values that light (8) incident in the row and column directions is converged near to the center of each said photosensitive section (2) corresponding to each said light converging lens (106').

28. A solid state image pickup device according to claim 27, wherein the shape of each said light converging lens (106) being set such that an arcuate portion length at the cross section in the row direction is shorter than an arcuate portion length at the cross section in the column direction.

29. A method of manufacturing a solid state image pickup device, comprising the steps of:

forming a plurality of image pickup elements at predetermined areas on the surface of a semiconductor substrate (1), said image

pickup elements each having a photosensitive section (2), a plurality of said photosensitive sections (2) being disposed generally in a matrix shape, and each said photosensitive section (2) having one side in the row direction longer than the other side in the column direction;

forming a plurality of transparent strip layers (11) above a plurality of said photosensitive sections (2) of said image pickup elements disposed in the column direction;

forming a photoresist layer on said semiconductor substrate (1) and said plurality of strip layers (11);

patterning said photoresist layer to form a plurality of photoresist layer pieces (6) in a matrix form, said plurality of photoresist layer pieces covering said strip layers above said photosensitive sections; and

thermally deforming each said photoresist layer pieces (6), and by using said thermally deformed photoresist layer pieces (6) and said strip layers (11), forming light converging lenses each having curvatures to refract light (8) incident in the row and column directions toward a corresponding one of said photosensitive sections (2).

30. A method of manufacturing a solid state image pickup device according to claim 29, further comprising a step of forming color filters (4_1; 4_2; 4_3) of optional colors between each said light converging lens (6', 11) and each said photosensitive section (2).

31. A method of manufacturing a solid state image pickup device, comprising the steps of:

forming a plurality of image pickup elements at predetermined areas on the surface of a semiconductor substrate (1), said image pickup elements each having a photosensitive section (2), a plurality of said photosensitive sections (2) being disposed generally in a matrix form, and each said photosensitive section (2) having one side in the row direction longer than the other side in the column direction;

forming a transparent film layer (106) above said plurality of photosensitive sections (2) for covering said plurality of photosensitive sections;

forming strip layers (11') on said transparent film layer (106) above said plurality of photosensitive sections (2);

forming a lens shape defining film on said transparent film layer (106) and said strip layers (11), etching said lens shape defining film to form lens shapes (6") above each said photosensitive section (2); and

etching said lens shapes (6"), said strip layers (11'), and said transparent film layer (106), and transferring said lens shape (6") to said transparent film layer (106) to form a light converging lens (106') above each said photosensitive section (2), said light converging lens having a thickness suitable for refracting light (8) incident to the row and column directions toward a corresponding one of said photosensitive sections (2).

32. A method of manufacturing a solid state image pickup device according to claim 31, further comprising a step of forming color filters (4_1; 4_2; 4_3) of optional colors between each said light converging lens (106') and each said photosensitive section (2).

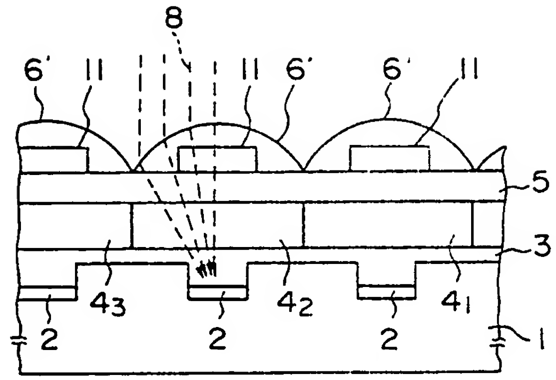


FIG. 1A

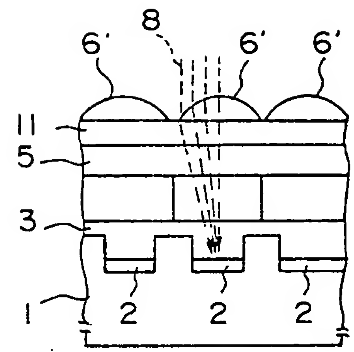


FIG. 1B

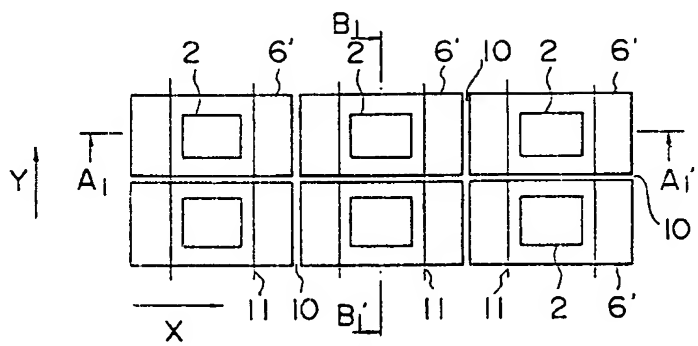


FIG. 1C

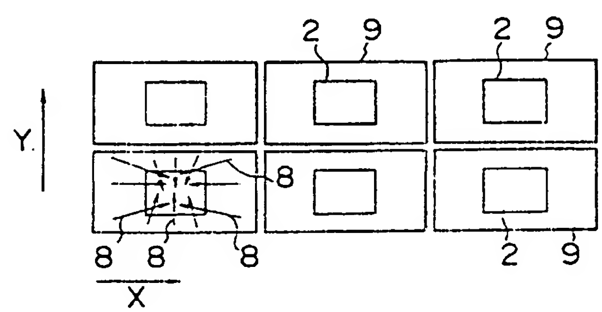


FIG. 2

FIG. 3A

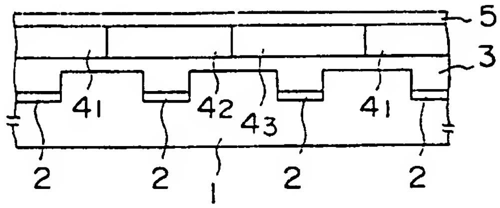


FIG. 3B

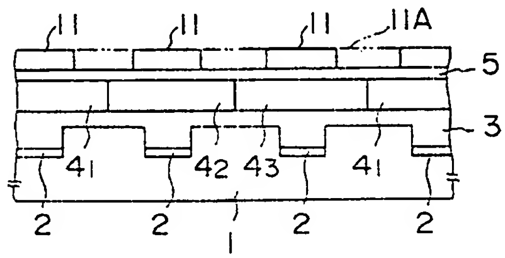


FIG. 3C

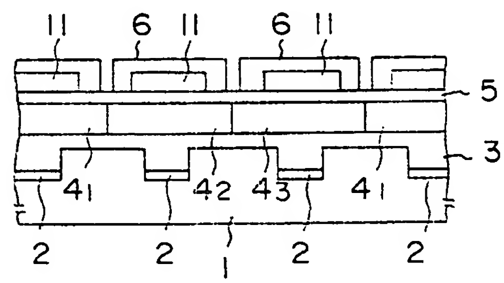


FIG. 3D

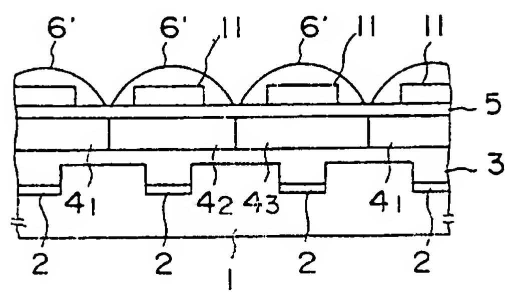


FIG. 4A

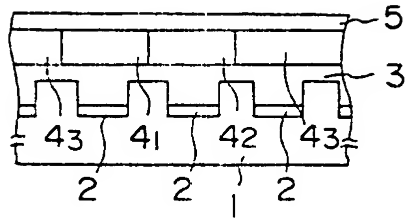


FIG. 4B

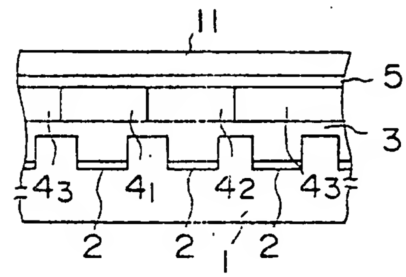


FIG. 4C

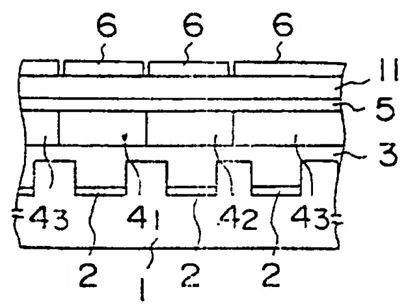
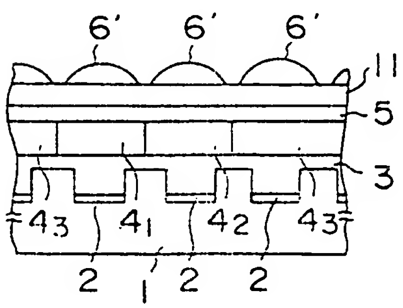


FIG. 4D



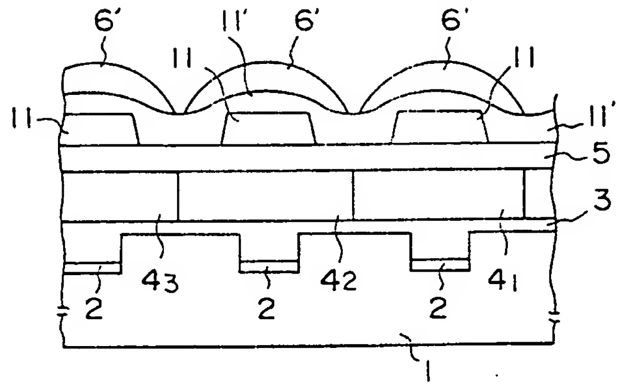


FIG. 5A

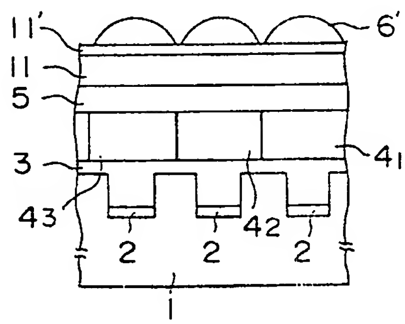


FIG. 5B

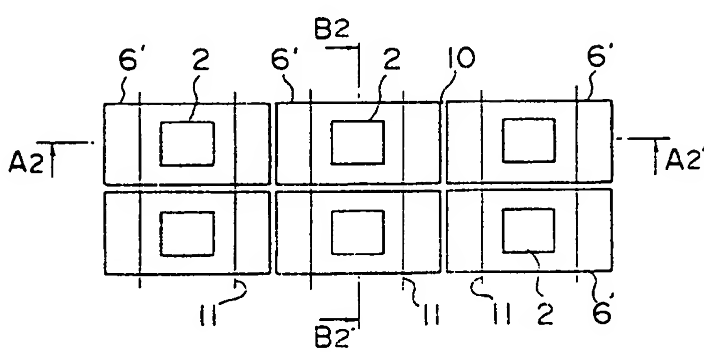


FIG. 5C

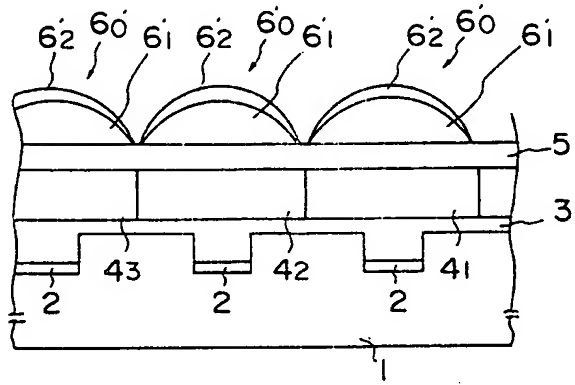


FIG. 6A

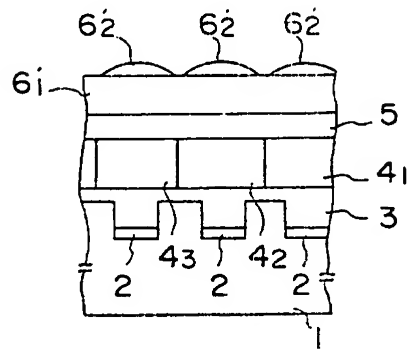


FIG. 6B

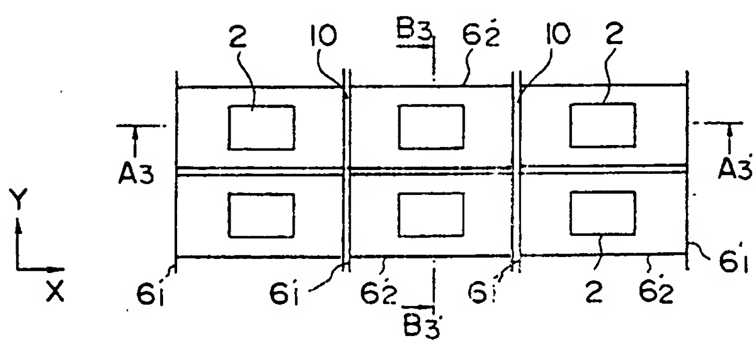


FIG. 6C

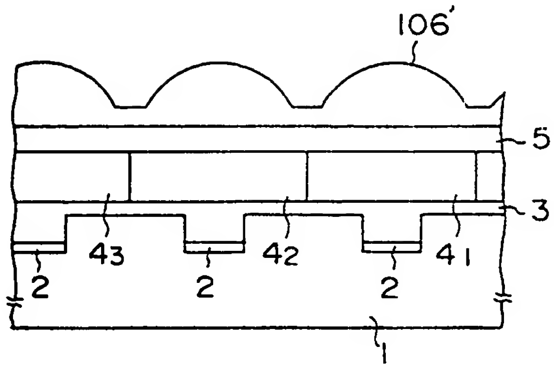


FIG. 7A

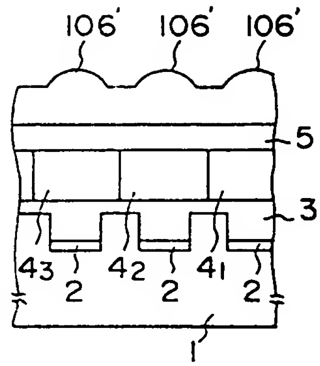


FIG. 7B

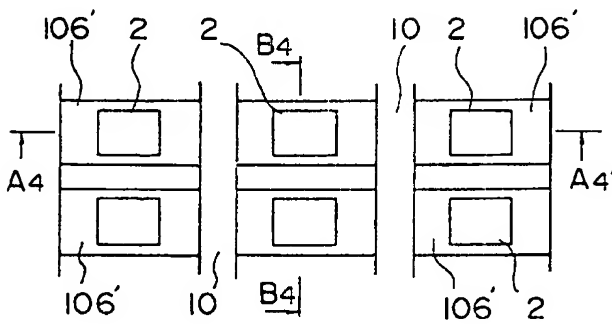


FIG. 7C

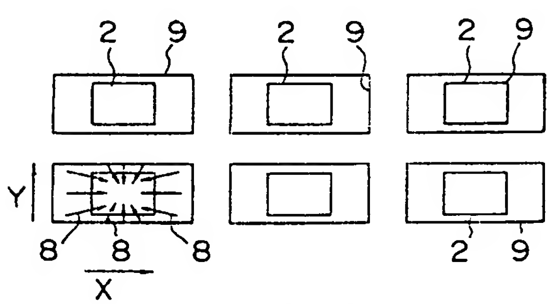


FIG. 8

FIG. 9A

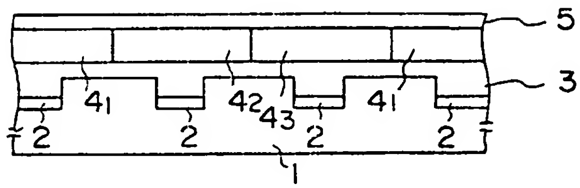


FIG. 9B

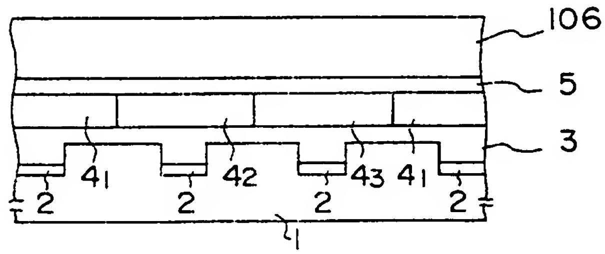


FIG. 9C

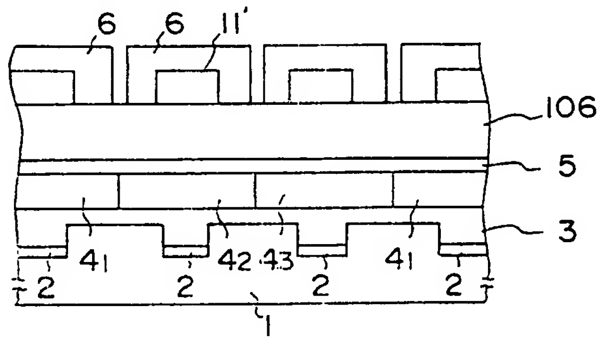


FIG. 9D

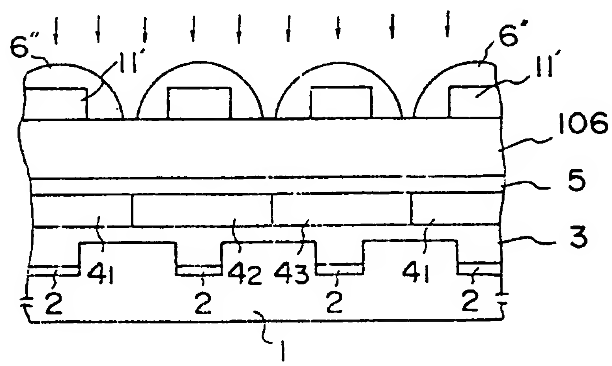


FIG. 9E

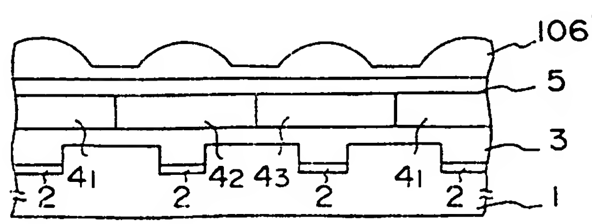


FIG. 10A

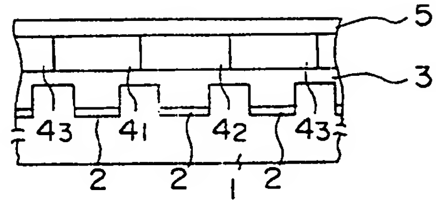


FIG. 10B

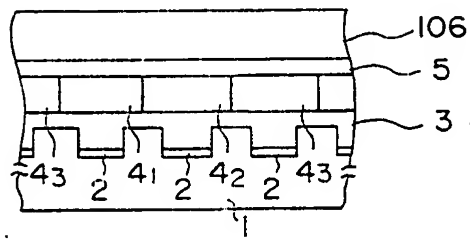


FIG. 10C

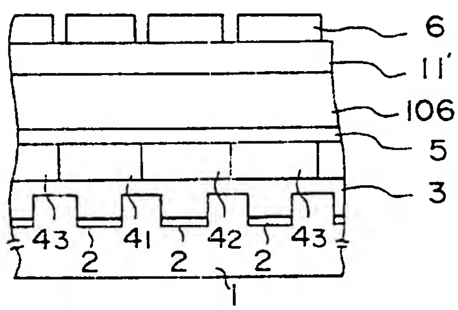


FIG. 10D

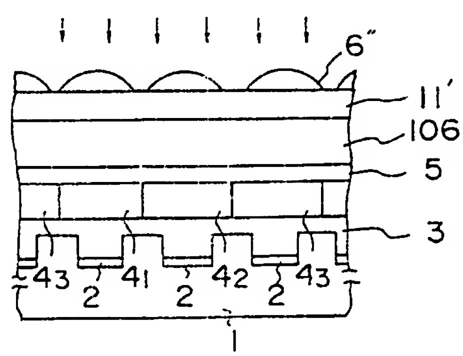
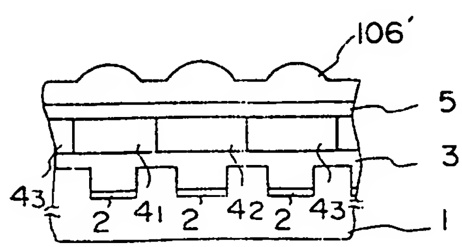


FIG. 10E



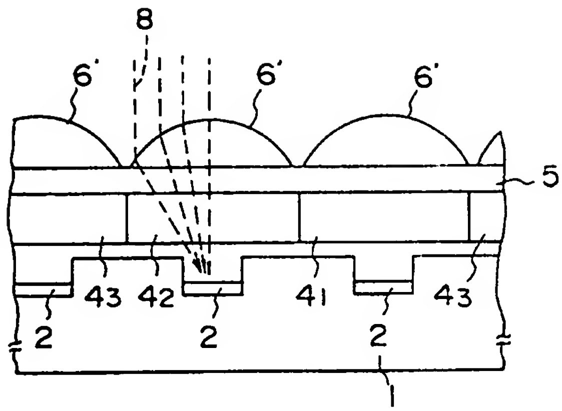


FIG. 11A

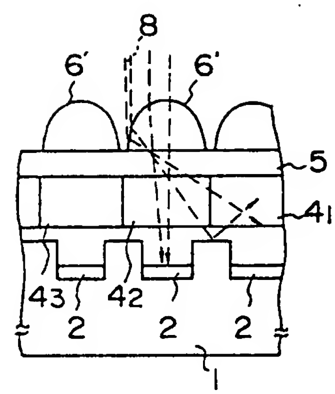


FIG. 11B

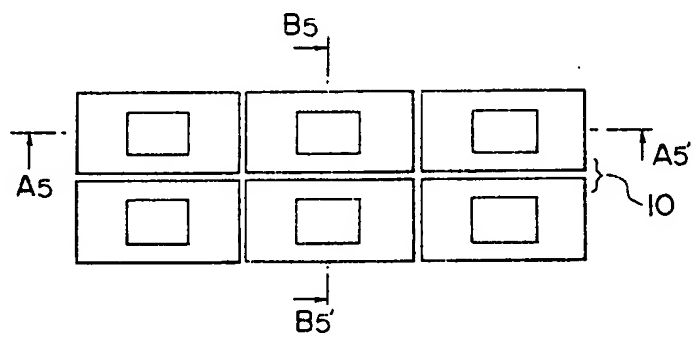


FIG. 11C

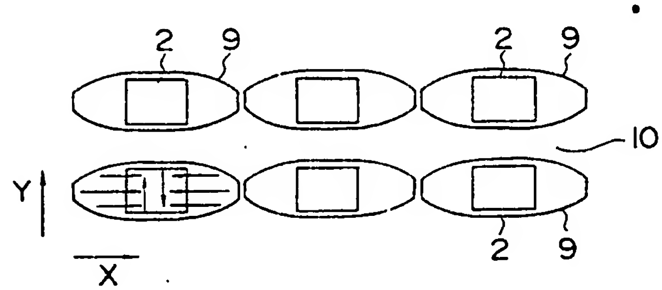


FIG. 12

FIG. 13A

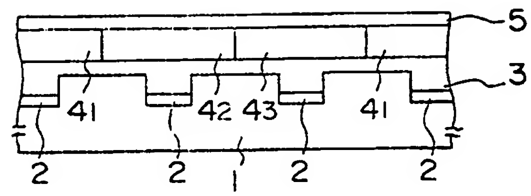


FIG. 13B

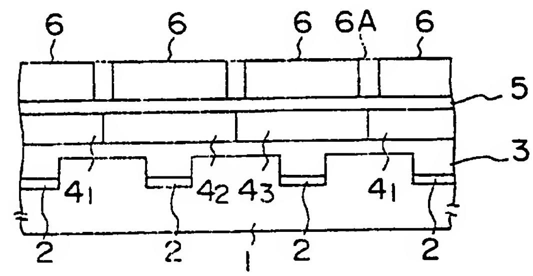


FIG. 13C

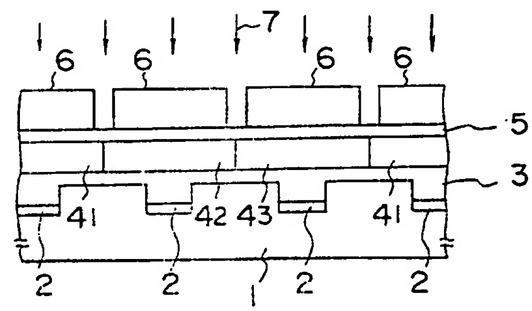


FIG. 13D

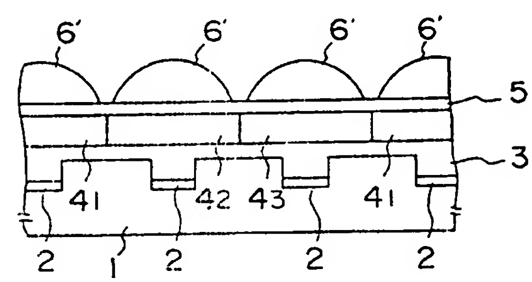


FIG. 14A

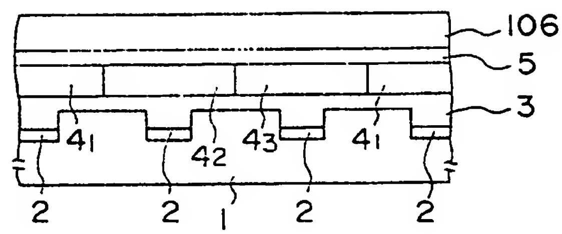


FIG. 14B

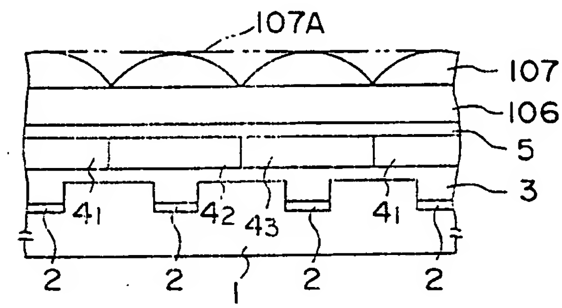


FIG. 14C

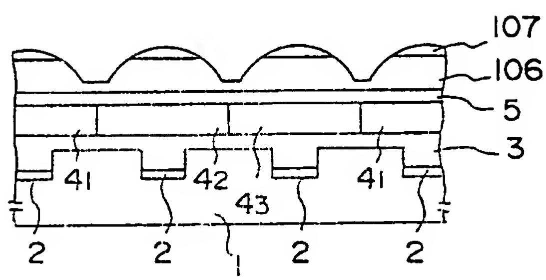
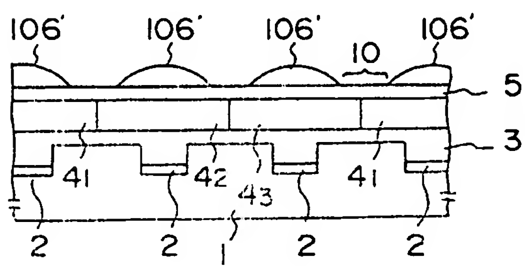


FIG. 14D



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP91/01567

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5] H01L27/146, H04N5/335

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	H01L27/14-27/148, H04N5/335

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1971 - 1990
Kokai Jitsuyo Shinan Koho	1971 - 1990

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	JP, A, 60-233852 (Victor Co., of Japan Ltd.), November 20, 1985 (20. 11. 85), (Family: none)	1-32
Y	JP, A, 59-90467 (Mitsubishi Electric Corp.), May 24, 1984 (24. 05. 84), (Family: none)	1-32
Y	JP, A, 02-248074 (Toshiba Corp.), October 3, 1990 (03. 10. 90), (Family: none)	1-32
Y	JP, A, 64-10666 (Sony Corp.), January 13, 1989 (13. 01. 89), (Family: none)	31, 32

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
February 10, 1992 (10. 02. 92)	February 18, 1992 (18. 02. 92)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	